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Using Technology as a Learning Tool: A Literature Review of Technology and Learning Outcomes

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To enhance learning outcomes, and to deal with recent shifts in distance learning, instructors are constantly challenged to create more engaging educational content, increasingly so through online platforms. Gaps in how technology is viewed and utilized can cause frustrations in the classroom. Traditional teaching has focused on visual, auditory, and kinesthetic learning styles (VAK); however, these methods are no longer meeting the dynamic engagement needs of students in higher education. Technology in the classroom has changed the way students and professors interact with the material presented, and educators have more ways than ever to adapt and improve communication of the material through learning management systems (LMS). This paper presents ways that higher-education instructors can create learning environments to foster understanding and curiosity, strategies to help students learn, and ways to bridge technological gaps in construction and architecture education. Through aa thematic literature review, this paper explores teaching and learning styles, strategies to help students, and differences between classroom and online learning. Findings from this review suggest the advances in technology for the classroom are changing the classroom landscape, including how in-class time can be spent, communication, assignment and assessment design, and the availability of resources for students.

Key Words: construction education; technology; learning styles; pedagogy; learning technology

Introduction

The digital age has shifted the way our society works and with it how the classroom landscape functions. To enhance learning outcomes, instructors are having to create more engaging content and provide new ways of learning to utilize the advantages that modern technology can offer (Gu et al., 2013). Higher-education instructors are working to create learning environments that foster understanding and curiosity, develop strategies to help students learn, and beginning to bridge technological gaps. Especially in design and construction classes, technology is challenging the way students and professors interact with the material presented, and educators have more ways than ever to adapt and improve communication of their material (Harasim, 2011).

This paper examines research surrounding how technology and other factors are changing the ways students are learning in the classroom, especially in the design and construction disciplines where so

many of the students are visual and hands-on learners (Day, 2015; Day & Orthel, 2015). The literature review begins by describing the various ways students learn and how their learning style is affected by a multitude of factors. How students learn can be a determining factor when introducing technology into a classroom. The next section explores different ways teachers can better understand their students and the relationships they have with them, making sure the technology introduced is helping students in the most effective ways. Finally, the studies presented describe the ways students are using technology both in and out of the classroom and how technology use can impact students, some ways being detrimental, and some being beneficial. Then, in the final discussion, comparisons between the studies examine evidence to support or refute the claims that learning through online platforms as seen through the SARS-COVID 19 pandemic, requires different teaching and learning styles compared to in person learning.

Methodology

This thematic pedagogical literature review was developed to investigate the variables that affect learning, specifically how technology has shaped the higher education classroom. The literature gathered for this review includes peer-reviewed journal articles and books from the academic, teaching, and technology fields, gathered to identify common topics, trends, and significant scholarly work. Peer-reviewed articles and well- recognized reviews were analyzed and organized into their related topics to make the collective information organized for reading. Additional articles, sourced from significant pieces of literature, led to further discoveries, and bolstered the content provided from multiple angles. Literature was searched through science direct, the researcher's university library system, and google scholar, using key terms such as learning styles, pedagogy, teaching technologies, construction education, student attention, adult learning, and academic impacts of pandemic. Portions of this literature review were narrowed to references published in the last 10 years, but significant research published before this date was included to provide historical context and comparisons of how approaches to teaching and learning have changed over time. Literature was gathered and analyzed to answer to the following leading research questions: *R1: How are students in higher education settings learning with the introduction of technology in the classroom? R2: How is technology changing the classroom landscape in the design and construction disciplines?* The following section highlights three key topics: how students learn, student relationships with their peers and instructors, and technology use in and out of the classroom. Each section of this literature review discusses the background of each respective theory and how it is relevant to digital teaching and the future of technology in the classroom.

Literature Review

Technology can be used as a useful learning tool in the classroom, but it can also be misused and distract from the learning experience. When learning about building science, for instance, or how buildings are built and operated, technology and the opportunities it provides are exceptionally helpful. For example, the digitization of the design and construction process provides opportunities for students in these disciplines to better understand the interdisciplinary nature of the construction process. The existing research on technology in the classroom primarily caters to how different students learn with technology-centric methods; however, it is also important to know how students best learn naturally. This thematic pedagogical literature review will investigate how technology and learning styles have changed in recent years and how educators are working to change their content delivery.

How Students Learn

Learning Styles are particularly important in understanding how technology can be best used to help students and educators create powerful learning environments. Learning Styles, or characteristics of how students absorb, process, and comprehend the information given to them, have previously been discussed by design and construction educators as a way to better understand their students, and cater their materials to help them understand spatial design problems (Mostafa & Mostafa, 2010). One popular theory adopts the idea that there are three main types of learners. The VAK method includes Visual Learners, Auditory Learners, and Kinesthetic Learners (Fleming & Mills, 1992). Understanding how people learn can change the way that educators teach their lessons (Price, 1983; Ralston et al., 1978). In design and construction education, a vast majority of students are visual learners who benefit from spatial and active learning methods (Mostafa & Mostafa, 2010). It is critical for design and construction instructors to understand the differing types of learners in their classroom to blend teaching material, tactics, and technology in ways that help the students best learn; often a mix of methods is required to achieve learning.

Coleman, Rourke, and Allen (Coleman et al., 2011) found that it is important to teach students in the way they learn best, which may seem obvious, but this may be overlooked by instructors as they try to get through course learning objectives as efficiently as possible. By providing instructional content to design and construction students through visual methods, a richer and more well-rounded education can be facilitated. Visual learning methods provide students with a better understanding of the "big picture" while providing multiple opportunities to learn the content (Coleman et al., 2011). Researchers also agree the way you show information to visual learners is crucial (Chen, 2020; Ibrahim & Kadiri, 2018; Knowles, 1990; Mayer & Massa, 2003). It is difficult to cater to different learning styles, especially in classes with over fifty students. Coleman et al. (Coleman et al., 2011) explores the way classrooms could work if they were set up to respond to student's visual inclinations as if they were experiencing the materials in "the real world." If colleagues could collaborate on their assignments and play to each other's strengths, each student would feel more confident in their part of the project, giving more confidence to the subject.

Understanding how people learn is especially important when selecting what technology will help students learn. The National Research Council (Council, 2000) examined how people learn by asking how to make student's ideas visible through a 2-year study conducted by the Committee on Developments in the Science of Learning , so that educators could see the ways students were learning in different environments. This is called the transfer of learning, which relates to how students can gather information, process it in their minds, and then relay it back to others. The conclusions found the importance of having a goal of learning to understand, as opposed to simply memorizing, had the greatest success in the transfer of learning. Similar to findings from Coleman et al. (Coleman et al., 2011), conclusions also highlighted that people learned best when they could apply their developed skills to help them in real-life situations. Furthermore, in higher education, learning occurs through in classroom and out of classroom activities, including online instruction, digital tools, through engagement activities or in-person projects. However, instructors may not understand the amount of time it takes for students to learn what has been taught, and students may not feel motivation to dedicate time to different modalities of teaching if they do not understand the benefit or the graded impacts of their work (Coffey & Clarke, 2021).

Students often learn and process in the same ways professionals learn in industry and professional practice (Li, 2019). Designers, for instance, are known for their ability to solve problems and using their creative skills and by the iterative process of design itself (Day & Orthel, 2015). In a study by Pavel (Pavel, 2017) about the ways designers learn, the analysis showed designers learn best through

visual stimulation. The primary way designers in this study communicated their knowledge was through visual applications. The study also looked at how different "visual objects of representation" meaning what tools were given to help the participants solve the problem and how they shaped the way the problem was solved by two diverse groups of designers. The participants were Masters of Arts design students, and the two groups were given the same objective, each with separate ways they were expected to deliver their ideas to the stakeholders. One group was given the materials and a direction to focus on to convey the solution to the problem, and the other group was given no guidance as to how they would need to communicate their solution. The group that was given direction and materials to use produced more creative and well-developed ideas. This small amount of direction helped the designers focus their energy on how to develop the best solution instead of spending wasted time trying to work out what to show for the solution. This study shows that when given expectations or ability to visualize what the outcome should be, students perform better. This finding is relevant to the format in which professors and instructors can design assignments and their expectations for the students to be successful.

Many studies that evaluate how students learn utilize question and answer formats to gain the needed information, studies that rely on participants reflection or observation throughout the study and how they learned through a given time period or type of teaching. Modern technology has made it possible to get quantitative as well as qualitative data about this topic. There have been several studies that correlate interest in a subject with a student's concentration and achievement. In a study at Jiangsu Normal University (Yang et al., 2013), researchers found there were strong correlations between interest and concentration during a presentation as well as between concentration and achievement. In another study, Yang, Li, and Lu (Yang et al., 2015) found mobile learning (on a cell phone) did not have a significant difference in the level of concentration from learning from a computer. The biggest factor in the concentration level of the student was how interested they were in the subject. In their study, they used "m-learning" as a term to describe mobile learning, which can be from a computer, tablet, or phone. They researched three types of m-learning: mobile learning, video-based, graphical, and text-based media and discovered differences in how forms of media affect student attention. They found it was important for instructors to know and understand how interested the students were in the subject because the type of media the instructor may need to vary if the student has a high, medium, or low interest. For instance, if a video is extremely in-depth about a concept, the more interested student may feel the amount of information is superfluous. However, when showing the same video to students with a moderate or low interest in the subject, the amount of information will pique their interest.

Technology can help decrease the amount of time spent on coordinating group projects, improving communication between members with ease. Colbeck, Campbell, and Bjorklund (Colbeck et al., 2000) studied how students felt about group projects, and the authors found that students appreciated the interactive learning experiences they received from group work. Further, a newer study found that project-based teaching (PBT) may enhance student interest in subject matter when course objectives and the connection to subject materials are well explained to students, (Gunawan et al., 2022). These studies align with findings from Bransford et al. (2005) who found that students who worked together through class projects and learned from each other's insights were better able to convey their thoughts to others. Many employers value the ability for their employees to work with teams and in collaborative environments, however, entry-level students may not understand the relevancy and real-world applications of the delivered content through lectures alone and require group-based activities to commit knowledge to skills. Applying social constructivist approaches to learning, such as relating in-class taught concepts to a group project, can greatly improve the learning outcomes of early-career construction students and their success when entering the industry (Brittle, 2021). If the technology being used is not a traditional platform, students will have to use additional cognitive function in order

to understand the program which will diminish their abilities to learn the intended material. By using widely adopted technology platforms for group-work, the negative aspects of these collaborative projects can be diminished. Through the SARS-COVID 19 pandemic the use of technology has shot forward because of remote learning, this change in the way curriculum is delivered has shifted the ways that instructors can connect with their students, but the more comfortable students and teachers alike become with the platforms they are using the focus on understanding technology shifts to again focus on fostering the relationships that are created in the classroom. Technology can be used to enhance the student learning experience in many ways as mentioned above, diversifying the student experience. Tools such as social media, virtual reality tools, and video viewing platforms can also be used to enhance the student-teacher relationship, improve student soft skills, and increased student engagement (Lucas & Gajjar, 2020). As students are more frequently requesting communication between their colleagues and instructors, various programs, and websites such as Microsoft Teams, Google Drive, and learning platforms like Blackboard, Google Classroom and Canvas help facilitate stronger communication networks than previously available in face-to-face only education models. However, it is important to remember that direct communication with students, clear instructions and expectations, as well as technical support and training on using these platforms is essential to student success in a virtual or flipped classroom setting, as seen through the lasting impacts of the pandemic (Camilleri & Camilleri, 2022). Access to feedback and clarification from instructors has become an integral part of the student-teacher relationship and can be facilitated through these platforms.

Technology in and out of the classroom

The world of education has changed dramatically in the past decade (and especially in the past year of facing a pandemic and virtual learning). As such, the use of mobile technology in everyday life has become the norm (Fidishun, n.d.; McWhirter & Shealy, 2020). Some researchers feel the amount of technology present in the lives of students today is simply a hindrance to education (Naomi, 2015). Others feel technology can facilitate deeper learning and provide new and unique experiences that may not be possible without the access to technology (Lloyd, 2000; Miller, 2014). Since these articles have been written, technology is the virtual classroom has been come a required way of life as students and instructors alike must work from home (i.e., in 2020, 2021) due to the impacts of COVID-19. In a flipped classroom model, students are more responsible for their learning through asynchronous materials outside of class, with more active in-classroom learning strategies (McWhirter & Shealy, 2020). There is still much to learn about how this work from home model and heavy use of technology has impacted overall learning outcomes, but is a promising strategy for construction engineering and management (CEM) education (Lee & Kim, 2021). This next section discusses the implications that technology has on students beyond the classroom, benefits and potential downfalls of using technology, and how the gaps are bridged in instructional settings.

Zhang, Russo, and Fallon, (Zhang et al., 2015) conducted a study to see if there was a correlation between college students' stress levels and their use of technology. They found that students who had self-imposed boundaries with technology, meaning they self-moderated their time, use, and reliance on technologies, experienced less stress from technology in their lives. While there are many positives to active use of technology in the classroom, this study found students also wanted to ask instructors to think about the need for technology for projects before assigning it. It is critical for students and instructors to be conscious of the amount of communication and information given to be within reasonable timeframes. While the connectivity granted through educational technology has benefits, instructors must also consider how over-connectivity can be overwhelming (Zhang et al., 2015).

Constant need to be connected for the sake of checking emails or deadlines has the ability to negatively affect student success and focus, and this study recommends that instructors first determine

their students' comfort levels using technology in educational settings and set clear boundaries and expectations for communications via technology early in a course. This method can also be beneficial in preventing burnout on the instructor's end as well.

McDaniel (McDaniel & Drouin, 2019) studied the effects of technology, or "technoference," and our ability to focus on what is in front of us. This research studied interpersonal relationships as well as the difficulty students had focusing on the material when technology use increased. Since many students are so closely attached to their technology, it can seem that technology is more important than the person in front of them, which can diminish social relationships, communication, and learning. His study found "technoference," when looked at through a social exchange model, provided a lens to examine the negative effects of technology of interpersonal relationships. The term McDaniel used to describe this type of distraction was called "phubbing;" phubbing is a combination of "phone" and "snubbing," which has been observed and studied by other researchers as a way to understand technological impacts on social interactions (Chotpitayasunondh & Douglas, 2016, 2018). When this concept is applied to the classroom, students on their phone may not be paying attention to the instructor, or the material being covered, often too immersed in another virtual setting. This does not create a healthy learning environment for the student nor the educator as the students are not learning to their fullest potential, and the educator does not feel respected, which may translate to having a more difficult time teaching the material effectively. This creates a negative association with technology for many instructors due to clear hindrances to the learning environment. If the context and use of technology in classrooms is changed, technology can become a tool providing them with the information they need to learn and be a positive aspect of the learning environment. In relationships of any kind, people want to feel that their time and effort is respected; when students are distracted, this can increase the feeling of disrespect in others in the learning environment, as well as for the instructor. If technology is not used in a conscious way, it can often lead to distraction and increased feelings of disrespect for those involved.

Technology Building Science and Construction Courses

Students learning building science or other design or construction-related topics, as mentioned before, benefit greatly from seeing what they are learning, as well as having the ability to apply their knowledge to solving problems. This can be made possible by traditional slide-deck visual formats and dynamic presentations, as well as through experiential learning formats, such as field trips and the creation of physical models and diagrams. Shaffer et. al. (Shaffer et al., 2015) studied how the use of technology in the classroom is helping educators better cater to individual students. Through his methods, he delivers course content entirely digitally, allowing students to receive content on their own terms and find activities that allow them to practice their skills on their own. He believes there are three main ways students can learn digitally: through digital workbooks, digital readings, and digital internships to simulate real-world practice. Digital workbooks simply digitized worksheets, like paper handouts, that are delivered through online learning platforms.

Digital readings are similar in nature, allowing students the ability to virtually take notes, while allowing instructors the ability to track progress and prompt students throughout a reading. Reaching students beyond the traditional classroom space, digital internships can help students feel like they are in practice and learn how to think about real-world problem solving without having the attached risks and commitments.

Experiential learning helps students to understand more deeply their subject matter with potential of applying and testing skills developed in the classroom (Collins & Redden, 2021). Transforming class settings that have associated "lab" time integrated into the course content, digital internships and workshops provide the opportunity for students to apply what they have learned and apply those skills to specialized projects. Field trips and other traveling opportunities become harder to coordinate as

class sizes grow. Creating digital experiences, such as virtual building tours or field trips, can replicate what you would learn in real life without the extra hassle or the often-extra cost. Shaffer found that technology can help create experiential learning opportunities while keeping the amount of time to prepare lessons and teach them similar to the time it would take to create a traditional lesson (Shaffer et al., 2015). Through the COVID-19 pandemic, these digital experiences have become the sole source of experiential learning opportunities.

In recent years, following the shift in industry to use of technology and digital models to expand the potential and detail of projects, a shift in skills taught to students must reflect needs from professionals in the work force. Integration of Building Information Modelling or "BIM" into coursework is a successful way to teach students practical technologies that they will use in practice, and it also enforces the technological adaptability that students need to comprehend complex systems and problems (Lorek, 2018; Noble & Kensek, 2014; Yan et al., 2011). Many design schools and studios are adopting digital methods of communication and documentation, encouraging students to familiarize themselves with emerging technology prior to entering the workforce.

Technology can create many positive opportunities in educational settings, but it is also important for students to have face to face interactions with their instructors and peers as well to meet their needs. In a study done in 2021 about students with high functioning autism, Reicher found that while many students are enjoying their school days from home, and some are even excelling with the online academic curriculum, they are struggling with the "hidden curriculum" students learn in face-to-face formats, which include learning societal and communication skills, traditionally learned through interactions with their peers (Reicher, 2021). While learning from home during the pandemic is benefitting many students (it should be noted that the opposite is also true for some students), extended periods without social interaction can hinder students' communication and ability to navigate life beyond school.

One of, if not the most difficult aspect of technology use in the classroom, is understanding when and how to use technology to best teach and transfer knowledge. Huffman and Huffman (Huffman & Huffman, 2012) studied how different external factors impacted students' effective use of technology and how students were expected to use technology against their actual performance in the class, if the students don't understand the technology, even if they understand the content, they will not be able to demonstrate they understand the content because they aren't able to correctly use the technology. The study found that students who felt there was a need for technology used it more, and further, those who felt technology was needed were more intentional with their technology use. Their study also found when a professor deemed technology necessary to use on a project, students were more likely to use the technology in an appropriate and useful way. This finding is significant, as student inclination to using technology in the classroom must be focused and clearly defined for their success.

Technology is developing rapidly, and college students of this digital generation using these technologies in everyday life. Lai and Hong (Lai & Hong, 2015) discussed the change in how students in university classrooms today have a very different style of learning than their parents. "Digital natives" is the term used to describe these students, and this study observed university students to determine if the term was indeed accurate. They found that most of the participants were digitally literate, however, they did not want digital technologies in every aspect of their learning. For example, many participants in the study noted that they preferred to do group work in person, as opposed to doing the work via technology, as communication between group members can be challenging (this is further supported by findings in previous sections of this literature review). The other major finding of this study was that even though technology has created a culture that likes immediate gratification and instant access to data, these students had moderate expectations for immediacy in their education.

This finding, supported by other studies, means that even though there are many parts of the students' lives that are filled with immediate answers, the learning environment does not need to be one of them (Lai & Hong, 2015; Shtepura, 2018). The idea that learning can take time, the answers are not always obvious, and care is needed to process and select the best answer in fostering critical thinking skills. Learning should be creative, interactive for students and their peers, as well as autonomous, meaning that they can learn through their devices intuitively. The prevalence of technology in modern students' lives has formed their skillsets and the ability to use technology to their advantage both in the classroom and through the rest of their lives.

Conclusions

To briefly sum up the findings of this body of research, the attention spans, and ways in which students are learning today is changing rapidly, in the past year with the restrictions from SARS-COVID 19 has changed the way that students are able to learn. Findings from this review suggest differences in how students learn is complicated but can be better understood by understanding how those students best learn on a class-by-class basis; for instance, providing a learning style quiz at the beginning of a semester or quarter may help inform instructors for how to best deliver materials, design the learning management system for best use, and improve learning outcomes. Research also suggests educators and students alike need to find common ground and learn from each other to create a more enjoyable learning environment for all. While the principles of learning have not changed drastically, the purpose of this paper is to help instructors improve the delivery and information students need to succeed, that are constantly changing as students and the world shift to different modalities of learning and teaching. Students still like to see what they are learning (and what is expected of them) written down, whether in physical form or virtually through presentations and reference documents, and clearly communicated in a consistent manner. Students want to know how projects, both solo and group projects, connect to their expected learning outcomes and the time commitment before starting the work, and need the ability to ask questions, suggesting flipped classroom strategies or hybrid methods of teaching construction students may benefit learning.

The educational approach has surely changed in the last few years, and the world of education is different too. All the changes that came about out of necessity due to the SARS-COVID 19 pandemic have proven that technology can be a great benefit and teaching tool for some students. While the world is shifting back towards a mostly "normal" state, these digitally accessible methods of using technology are going to continue to prove themselves a useful tool for students and educators alike. Technology has changed the classroom landscape drastically, but the backbone of education is not technology, it is learning, and technology can be used as a tool to assist that process drastically. Future research should further explore the connection between learning and technology in and out of the classroom. It will be even more critical as learning modalities change after the COVID-19 pandemic, and continue to evolve, to ensure students are using tools in the classroom that help them best learn for architecture and construction disciplines.

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